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An Evaluation of Sprayable Latex Mulches in some Forestry Applications

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Introduction

Mulching is widely used in forest tree nurseries for seedbed stabilization before, during and immediately after germination (Mullin 1965, Clifford and Massello 1965, Barham 1980, Racey and Raitanen 1983, Landis et al. 1984). Some mulches are of questionable benefit and some widely used mulches, such as sawdust, have side effects, such as contributing to nutritional imbalances (Bollen and Lu 1957). In addition to nursery applications, mulching is also used on exposed or easily eroded soils to increase regeneration success. A detailed examination of mulching techniques for disturbed soils is presented by Slick and Curtis (1985). However, mulches are not normally used in forest regeneration.

Soil moisture is important for tree establishment and root temperature influences root vigor (Larson 1970, Cooper 1972). Both of these parameters are influenced by many mulches because they have the ability to modify soil temperature and improve moisture retention.

Sprayable latex mulches are somewhat unique in that they are synthetic, yet may be appplied at will on irregular terrain. In addition, colour, viscosity and elasticity can be modified to produce desired properties.

The purpose of this research was to evaluate some of the effects of sprayable latex mulches on 1/ a plant's growing environment, 2/ nursery seedbed stabilization, 3/ seed germination rates and 4/ seedling performance after outplanting.

Materials and Methods

Two types of sprayable latex mulch products were evaluated, one with a $CaCO_3$ filler and the other without. Pigment was added in accordance with manufacturers preference. The mulch films created by these products varied in colour, texture, resiliance and durability. Clean up was achieved by washing nozzles and filter screens with a soap solution after each plot or latex sample was applied. Spray apparatus was difficult to clean for all latex products tested. The difficulty in cleaning was proportional to the length of time the mulch was exposed to air. Warm soapy water readily emulsified the liquid product but physical methods were needed to remove the skin or film left in the tank, valve or wand of the sprayer. Film left in the tank between uses often separated upon re-use, and contributed to clogging.

Environmental Modification

Three study sites were selected at the Midhurst Research Unit for the study of environmental modification; 1/ uncultivated fine sand with grass, 2/ cultivated sand and 3/ previously cultivated clay-loam soils with no recent land preparation. Each trial was organized in a randomized complete block design with five replications of nine treatments each consisting of a four foot square plot.

Mulch was applied to the sites 17 April 1985. Room temperature products were taken to the field, shaken, and poured directly into Solo backpack sprayers fitted with Tee-Jet SS80003 nozzles. Mulch was applied uniformly to the treatment plots for 40 seconds (200-270 gm^{-2}) for a light application rate, and 60 seconds (300-500 gm^{-2}) for a heavier application rate. The distance between the sprayer nozzle and the ground was approximately 20 cm. The nine treatments consisted of a control (no mulch) and a high and low application rate of a black and light coloured mulch from each of the two manufacturers. After all the treatments were applied, the

mulches were visually inspected for quality of film, soil penetration, adhesion, and uniformity of application.

Soil Relative Moisture Content (RMC) was monitored periodically on soil samples (15 cm deep x 1.9 cm diameter) taken from the treatment plots.

$$RMC = \frac{\text{Oven dry weight - Fresh weight}}{\text{Oven dry weight}} \times 100$$

Daytime soil temperature monitoring was done with a multipoint Thermo-Electric Recorder[1] attached to three identical thermocouple insertion rods. These rods were inserted into a dark mulch plot, a light mulch plot and a control treatment plot at each set-up time. Air temperature was measured at 14 cm above grade, and soil temperatures were measured at 1 and 15 cm below grade for a period of 8 hours on each sampling date.

Weed growth on the mulched plots was observed over the growing season as was film durability.

Seedbed Trials

Mulching trials for seedbed stabilization were established in a randomized complete block design on operational seedbeds at both Midhurst (44°27'N, 79°46'W) and Kemptville (45°03'N, 75°39'W) nurseries. Latex mulch was applied with a Solo backpack sprayer to treatment plots. Treatment plots were 30 cm long, and the entire width of the nursery bed (106-122 cm) with small (10 cm) buffer strips between plots.

The mulches were well agitated and filtered prior to application with a Tee-Jet SS80003 nozzle. Light application rates were obtained with a 3-second pass across the seedbed. Heavy application rates were achieved using three, 3-second passes. After each product was sprayed, the sprayer, filters, nozzle and pump mechanism were rinsed with a soap solution.

Soil temperature monitoring was carried out on the seedbeds at a depth of 3-5 mm near the centre of the seedbed. Temperatures were measured with a Digi-Sense thermocouple model 8529-00[2] at mid morning on several days during germination.

Seedbed germination was assessed on two 7.5 cm transverse samples representing .18 m^2 per plot at several times during the growing season to determine if differences in germination rates existed among mulch treatments.

Sampling to determine final seedbed density and seedling morphology was done Oct 15, 1985. Average stem diameter and top and root dry weights were determined for 25 tree samples from each treatment plot in each replication. Results were analysed by an analysis of variance.

Outplanting Trials

Outplanting trials were carried out on three sites located near Kirkland Lake, Espanola and Midhurst (Table 1). Both dark and light coloured mulches were sprayed at a relatively heavy application rate (300-500 gm^{-2}) with the intent of creating a water impervious film. The nozzles were held approximately 15-20 cm from ground level and a 1960 cm^2 circle of mulch was applied around the base of each tree using a 6 second spray. The outplanting trials were assessed for height, current annual increment and survival at the end of the first growing season. Results were analysed by an analysis of variance.

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[1] Westronics Inc. (Model No. 3518-3000), Ft. Worth, Texas.
[2] Cole-Parmer Instrument Company, Chicago, Illinois.

TABLE 1 First year field performance of four stock types outplanted at 3 locations in Ontario and treated with latex mulch. Numbers followed by the same letter are not significantly different at the 5% level.

Product	Total height (mm)	Current annual increment (mm)	Survival (%)
Kirkland Lake			
Jack pine container stock			**
Control	160	40 a	95 bc
General Latex - clear[1]	160	40 a	100 a
General Latex - clear[2]	160	40 a	99 ab
General Latex - dark[1]	160	25 b	82 c
General Latex - dark[2]	165	40 a	97 ab
	ns	*	*
Espanola			
Red pine			
Control	170	85	99
General Latex - dark[3]	165	85	96
General Latex - light[3]	165	85	100
Polysar - light	160	80	100
	ns	ns	ns
Midhurst			
White pine			
Control	210	60	99
General Latex - clear[2]	225	75	100
General Latex - dark[2]	245	75	100
Polysar - light	250	80	100
Polysar - dark	225	65	100
	ns	ns	ns
Midhurst			
White spruce			
Control	240	65	98
General Latex - clear	245	60	100
General Latex - dark	245	60	100
Polysar - light	260	60	99
Polysar - dark	255	65	100
	ns	ns	ns

* significant at 5% level
ns not statistically significant
1 General Latex product #1
2 General Latex product #2
3 General Latex products 1 and 2 were used on alternate replications.

The Espanola site was situated on deep fine sands and was scarified with a blade rake. Kemptville 2+0 red pine (Pinus resinosa Ait.) were operationally planted May 8, 1985. The next day the site was staked in a randomized block design with six replications of five treatments of approximately 25 trees each and mulch treatments were applied.

The Kirkland Lake outplanting site was on sandy-loam soil with glacial till and was scarified by Youngs teeth. Jack pine (Pinus banksiana Lamb.)

container stock was operationally planted on May 15, 1985. On May 16 a randomized trial was set up with six replications of five mulch treatments with ten trees per treatment.

The Midhurst outplanting site had a clay-loam soil, summer fallowed the previous year. On May 15, 1985, 100 trees each of spring lifted 3+0 white spruce (Picea glauca (Moench) Voss) and 3+0 white pine (Pinus strobus L.) were planted. The following day, mulches were applied in a randomized complete block design with twenty replications of five single-tree plots.

Results and Discussion

Environmental Modification

None of the mulches exhibited good adhesion to firmly packed or untilled soil. Cracking and peeling of the mulches was common, making them susceptible to removal by wind and water. Cracking was most pronounced on the mulch with the $CaCO_3$ filler. Adhesion to irregular surfaces was quite good.

Weed control is an additional benefit provided by most mulches, even if their original purpose was moisture retention or soil stabilization. The mulches used in this trial offered no protection from weed or grass growth when the root systems or seeds were covered by the mulch at the densities applied. Grass and weeds easily penetrated the film and contributed to an increased rate of breakdown. In early spring, it was apparent that the dark mulches enhanced the growth of perennial plants, probably due to increased soil temperature.

The latex mulches, generally increased the relative moisture content of the soil above the values attained in the control plots (Table 2). The difference between the control and the mulched plots was dependent upon weather over the preceding 2-3 days. No differences in relative moisture content were observed on site 1 where a light grass and moss mat were in existence prior to mulch application. The largest differences were observed on site 2 where a relatively level, well prepared surface allowed for good film formation.

The general reduction in relative moisture content over time can be attributed to two factors: 1/ the breakdown or cracking of the mulch film and 2/ the gradual drying of the surrounding soil. The heavier application rates provided the best moisture retention.

Early season warmth in the rooting zone of many plants contributes to vigourous root growth. Dark latex mulches significantly increased soil temperature at 15 and 1 cm below the soil surface (Figs. 1 and 2). At the same time, the black mulch reduced the air temperature 14 cm above the soil surface. Little difference was observed in temperatures between the control and the light coloured mulch treatments. This demonstrates that temperature modification of soil can be achieved with the use of pigmentation in the latex mulches. The soil-warming effect of the black mulches was reduced as encroaching vegetation produced shade and night time temperatures increased with the season.

Seedbed Trials

Seedbed stabilization against rain and wind is the major reason for using mulches in forest tree nurseries. Moisture retention is not a concern as nurseries generally have a good water supply and an excellent irrigation network.

TABLE 2 Relative moisture content of soil under various latex mulches. Site #1 was compacted grass over fine sand, site #2 was a sandy soil, freshly tilled and compacted and site #3 was a sandy loam soil, fallowed the previous year with some weeds and grasses intruding. Numbers followed by similar letters are not significantly different at the 5% level.

Treatment			Site 1		Site 2			Site 3	
Company	Product or colour	Application rate	May 1	May 15	Apr 25	Apr 30	May 15	May 1	May 15
Polysar	light	heavy	7.07	6.34	10.27 ab	9.27 abc	7.72 ab	10.10 abc	7.72
Polysar	dark	heavy	7.09	5.55	9.43 bc	9.08 abc	7.29 bc	8.95 cd	6.60
Polysar	light	light	6.66	5.93	9.65 bc	8.80 bcd	7.84 ab	10.86 ab	7.25
Polysar	dark	light	6.90	6.37	9.35 bc	8.65 cd	7.48 abc	9.49 bcd	7.06
General Latex	clear[1]	heavy	--	--	9.90 bc	9.95 ab	8.60 a	11.34 a	8.19
General Latex	clear[2]	heavy	7.00	5.46	--	--	--	--	--
General Latex	dark[1]	heavy	--	--	10.67 a	10.27 a	8.13 ab	10.54 ab	7.18
General Latex	dark[2]	heavy	6.20	5.61	--	--	--	--	--
General Latex	clear[1]	light	--	--	9.16 c	8.86 bcd	7.02 bc	10.05 abc	7.67
General Latex	clear[2]	light	6.59	5.74	--	--	--	--	--
General Latex	dark[1]	light	--	--	10.13 ab	9.30 abc	7.66 ab	9.94 abc	7.56
General Latex	dark[2]	light	6.50	5.58	--	--	--	--	--
Control			6.63	5.43	9.13	7.55 d	6.45 c	8.06 d	6.22
			ns	ns	*	*	*	*	ns

1 General Latex product #1
2 General Latex product #2
ns not statistically significant at the 5% level
* statistically significant at the 5% level

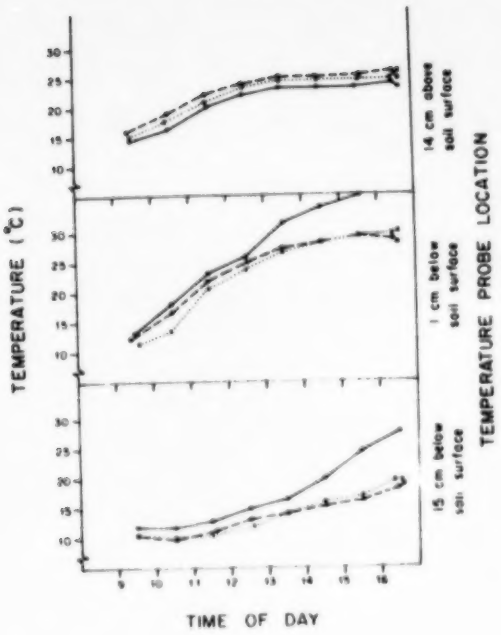

Figure 1 Air and soil temperatures at 3 locations on dark mulched (solid line), light mulched (dashed line) and control plots (dotted line). Monitoring was done on site 2, April 30, 1985. The black mulches enhanced soil temperature while reducing air temperature 14 cm above the soil surface.

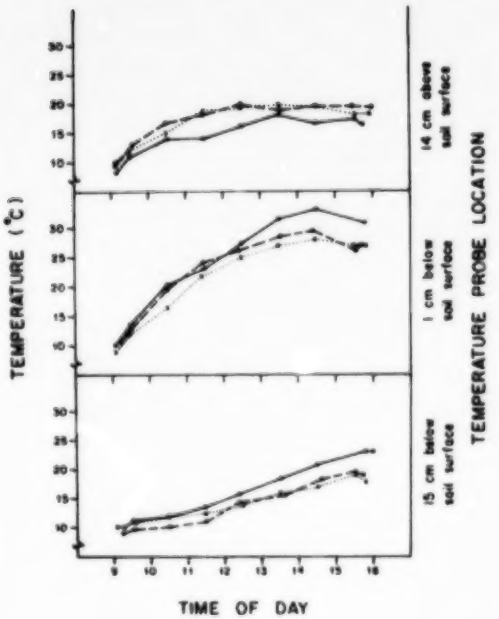

Figure 2 Air and soil temperatures at 3 locations on dark mulched (solid line), light mulched (dashed line) and control plots (dotted line). Monitoring was done on site 2, May 3, 1985. The black mulches enhanced soil temperature while reducing air temperature 14 cm above the soil surface.

Mulching practices vary from nursery to nursery. Mulch products include coarse sand, wood fibre hydromulch (Landis et al. 1984) and recycled newspaper hydromulch (Racey and Raitanen 1983). These products are cheap and relatively easy to apply, but do not always provide the desired degree of protection. The latex mulches were relatively easy to apply provided the spray nozzles remained free from clogging.

At low rates of application, the latex mulches did not provide an increase in seedbed stability over existing mulch products. Heavier application rates provided seedbed stabilization comparable to that attained by applying Fibramulch at a rate of 0.25 to 0.3 kg/m of bed. Seedbed temperature was modified by latex mulches (Tables 3 and 4). The dark mulches and to a lesser degree, heavier application rates of all mulches increased seedbed temperature above the values of the control plots. However, by mid June, these had been reduced due to shading from the new germinants and sand deposited by wind.

No significant differences in final seedbed density were observed with Midhurst red pine (136/m^2) and white pine (203/m^2) or Kemptville white spruce (433/m^2) and white pine (359/m^2). Also, there were no significant differences in seedling morphology at the end of the growing season at

TABLE 3 Seedbed temperatures in relation to mulching treatments on two compartments at the G. Howard Ferguson Forest Station in Kemptville. Temperatures were measured May 27, 1985, approximately 3 to 5 mm below the soil surface. Numbers followed by the same letter are not significantly different at the 5% level. Compartment B-14 was seeded May 2 and mulched May 3 and compartment 27 was seeded April 26 and mulched May 2, 1985.

Company	Product colour	Application rate	Seedbed temperature °C	
			Compartment B-14	Compartment 27
General Latex	clear	light	30.0 c	30.4 c
General Latex	clear	heavy	29.0 c	--
General Latex	dark	light	31.2 b	32.2 a
General Latex	dark	heavy	32.6 a	--
Polysar	light	light	--	29.8 c
Polysar	black	light	--	31.6 ab
Control			29.4 c	30.6 bc
			*	*

* significant at 5% level

TABLE 4 Seedbed temperatures in relation to mulching treatments on two compartments at the Midhurst Forest Tree Nursery. Temperatures were measured on 2 dates at a depth of 3 to 5 mm below the soil surface. Numbers followed by the same letter are not significantly different at the 5% level. Compartment C3 was seeded May 16 and mulched May 21 while compartment K4 was seeded May 10 and mulched May 14, 1985.

Company	Product colour	Application rate	Seedbed temperature			
			C3		K4	
			May 29	June 21	May 29	June 21
Control			23.8 c	30.4	27.1 dc	30.8
Control			23.7 c	30.3	28.1 abc	31.2
General Latex	dark	light	23.9 c	30.5	27.5 bcd	31.1
General Latex	dark	heavy	24.6 b	30.3	28.7 a	31.4
General Latex	clear	light	23.9 bc	29.5	28.0 abcd	31.3
General Latex	clear	heavy	25.2 a	30.4	27.2 cde	31.4
Polysar	dark	light	24.0 c	30.3	28.2 ab	30.9
Polysar	dark	heavy	25.4 a	31.3	28.7 a	31.2
Polysar	light	light	23.9 bc	30.4	26.9 e	31.7
Polysar	light	heavy	24.2 bc	30.4	27.1 de	30.8
			*	ns	*	ns

* significant at 5% level
ns not statistically significant

Midhurst. Seedling size was small but acceptable with stem diameter, top dry weight and root dry weight of 0.172, 2.49 and 1.14 for red pine and 0.138, 2.50 and 1.31 for white pine respectively. However, at Kemptville, significant differences in seedling weight were realized in both the spruce and white pine (Table 5). Spruce seedling size was reduced by heavy application rates. The control treatment produced spruce seedlings with the largest mass. In white pine, only the Polysar black mulch contributed to a reduced root mass.

Field Performance

The crucial test for latex mulches in the field is the field performance of trees under normal growing conditions. No differences in first year outplanting performance were observed in the Espanola red pine plantation or the white pine or white spruce outplanted at Midhurst (Table 1). Small but statistically significant differences in survival and current annual increment were observed in the jack pine container stock outplanted near Kirkland Lake, where the site conditions were relatively severe. Growing conditions on the other 3 plantations were good. The mulches applied at both Kirkland Lake and Espanola, maintained film integrity to a large degree. The General Latex product without the $CaCO_3$ filler maintained its glossy black appearance but the Kirkland Lake jack pine treated with

TABLE 5 Final morphological charcteristics for 1 year-old white spruce and white pine seedlings grown under fine spray mulch treatments (n = 250) in two compartments of the G. Howard Ferguson Forest Station in Kemptville. Numbers followed by similar letters are not significantly different.

Treatment		Application rate	Stem diameter (cm)	Top dry weight (g)	Root dry weight (g)
White spruce					
General Latex	clear	light	.097	1.51 ab	.70 a
General Latex	clear	heavy	.100	1.46 b	.70 a
General Latex	black	light	.103	1.71 ab	.85 a
General Latex	black	heavy	.098	1.33 b	.63 b
Control			.103	1.96 a	.86 a
			ns	*	*
White pine					
General Latex	clear	light	.117	3.38	2.22 ab
Polysar	white	light	.119	3.43	2.26 a
General Latex	black	light	.114	3.25	2.16 ab
Polysar	black	light	.117	3.24	2.08 b
Control			.119	3.43	2.31 a
			ns	ns	*

ns = not statistically significant
* = significant differences at 5% level

this product suffered from browning and had significantly poorer survival and terminal elongation. The back latex mulches may at some times create conditions of excessive heat which is not conducive to good growth.

Operationally, sprayable latex mulches do not appear to be promising. The preliminary results show that the benefits would be marginal. Problems with clogging would have to be overcome and a mechanized sprayer would be essential for efficient application.

Despite the lack of encouraging results from the outplanting performance trial, sprayable latex mulches may have some value in establishing difficult to regenerate sites, such as dunes, gravel or sand pits, abandoned quarries or shallow soil over bedrock. The cost and difficulty in establishing trees on these sites under normal conditions may justify the additional costs of applying a circle of mulch around each tree for moisture retention and soil stability.

Conclusion

The results of this study demonstrate that the desirable properties of moisture retention, temperature enhancement and soil stabilization can be achieved with sprayable latex mulches. These properties were desirable in theory but we were unable to detect statistical or biologically significant improvements in seedbed or field performance of common conifer trees. In addition the cost and absence of a suitable spraying technology indicate that sprayable latex mulches have limited, if any, role at this time in the forestry applications tested.

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